UNIVERSITY OF MANITOBA

EXAMINATION PAPERS
1919-1920

CIVIL SERVICE

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

First Year

ALGEBRA

1. Enunciate the binomial theorem, giving the conditions under which the expansion is valid. Evaluate: (*a*) the 5th term of $(6a-3)^{\frac{8}{3}}$, (*b*) the $(r+1)^{th}$ term of $(2-x)^{-2}$ and (*c*) the coefficient of x^n in $\frac{x^2-2}{(x^2+x)^2}$ expanded in ascending powers of x. Use (*b*) to write down the first four terms of $(2-x)^{-2}$. Find the approximate value of $\frac{(27+x)^{\frac{2}{3}}}{(1+x)\sqrt{9-2x}}$ where squares and higher powers of x may be neglected.

2. Explain carefully the reason why the mantissa of the logarithm of ordinary numbers is independent of the position of the decimal point. Given log 1.06 = .0253, (*a*) find the value of $\sqrt[3]{.0106}$ (log 2.197 = .3418); (*b*) find the number of digits in the integral part of $(10.6)^{20}$; and (*c*) find the annual tax which placed in a sinking fund for each of 20 years will be sufficient to meet $60,000 debentures at the end of that period (log 3.217 = .504).

3. Define e^x and prove that $e^x = 1+\frac{x}{1}+\frac{x^2}{\underline{|2}}+ \ldots\ldots$

Deduce the sum of $1+\frac{1}{\underline{|3}}+\frac{1}{\underline{|5}}+ \ldots\ldots$ to infinity.

4. Prove that $\log_e(1+x) = x-\frac{x^2}{2}+\frac{x^3}{3}- \ldots\ldots$ and de-

(over)

duce $\log_e (n+1)-\log_e (n-1)=2\left\{\frac{1}{n}+\frac{1}{3n^3}+\frac{1}{5n^5}+\ldots\right\}$.

From these results or otherwise, indicate how the logarithms of the integers 1,2, . . ., 10 to the base e are computed. Explain how logarithms of these numbers to the base 10 are derived and work out any one case (except 1 and 10) to 2 places of decimals.

5. Find the limit of $\frac{1-x^2}{1+x^3}$ as (*a*) x approaches 0, (*b*) as x approaches infinity, (*c*) as x approaches -1 and (*d*) as x approaches $+1$.

6. Prove by mathematical induction that the sum of n terms of the series $1^2+3^2+5^2+\ldots+(2n-1)^2=\frac{n}{3}(4n^2-1)$

7 If an equation of degree n has more than n roots, prove that each of the coefficients of the equation is 0. Use this result to prove the identity:

$$\frac{(x-b)\,(x-c)}{(a-b)\,(a-c)}+\frac{(x-c)\,(x-a)}{(b-c)\,(b-a)}+\frac{(x-a)\,(x-b)}{(c-a)\,(c-b)}=1.$$

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

First Year

GENERAL ASTRONOMY

1. Explain the cause of atmospheric refraction, and its effect on astronomical observations.

2. A new star has just been discovered and its position is announced thus: $\alpha = 20$ hr., $\delta = 10°$. Where would you look for it on December 21st at 8 p.m.? What would be its altitude and azimuth then? (Explain by a diagram.) Would it be near any first magnitude star? At what time on December 21 would this star be on the meridian?

3. Define *sidreal day* and *solar day*. Which of these is the longer, by how much, and why?

Define *mean solar day*. Give two reasons for the variation of the length of the true solar day, and explain one of them.

What is the "equation of time?"

4. Explain the phenomenon known as *aberration of light*. Find the constant of aberration, assuming the velocity of light to be 186,330 miles per second, and the velocity of the earth in its orbit about the sun to be 18.5 miles per second.

5. Write briefly on the sun under the following heads: (*a*) physical structure; (*b*) sun spots.

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

First Year

ARCHITECTURE

First Year

DESCRIPTIVE GEOMETRY

1. AB is a given line in space, X is a given point in space. Find the traces of plane passing through the given point perpendicular to the given line.

2. AB and BC are two given intersecting straight lines. Find the angle between them.

3. Find the distance of a given point X from a given plane LMN.

4. AB and CD are two given straight lines not in the same plane. Find the shortest distance between them.

5. An oblique plane makes an angle α with the horizontal plane and an angle β with the vertical plane. Find the traces of the plane.

6. An hexagon prism stands on the horizontal plane with its axis vertical. Find the line of intersection of the surfaces of the prism with a plane inclined to its axis. Make a development of the prism below the cutting plane.

7. A rectangular pyramid is cut by a plane inclined to both the horizontal and vertical planes. Find the line of intersection of the surfaces of the pyramid with the plane. Develop the surfaces of the pyramid below the cutting plane.

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING

First Year

DESCRIPTIVE GEOMETRY

1. Pass a plane tangent to a cylinder and parallel to a given straight line.

2. Through a point without the surface of a cone pass a plane tangent to the cone.

3. Find the intersection of a right cylinder with a circular base by an oblique plane.

4. Construct a triangular pyramid, having given the base and the three lateral edges.

5. The axes of two pipes intersect each other at an angle of 60°. Find the line of intersection of their surfaces. Develop the surfaces of both of the pipes. Explain the construction.

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING

First Year

DRAWING (PRACTICAL)

Note—Marks will be assigned for neatness, accuracy and general appearance.

1. A 1¾-inch pipe intersects a 2-inch pipe so that their axes are offset ⅜-inch and make a right angle with each other. Find the line of intersection of the surfaces. Develop the surfaces of the two pipes. Assume the additional dimensions.

2. From the model submitted (tool holder post) make freehand sketches and place on all necessary dimensions. From the sketches make a finished working drawing, showing all necessary views. Place the dimensions on neatly and accurately. The freehand sketches must be attached to the drawings when handed in.

3. Three spheres, A, B and C, rest on the horizontal plane but do not touch each other. Their centres are at different distances from the vertical plane, 2¼ inches, 1¾ inches and 3½ inches respectively. Their diameters are 3 inches, 1¼ inches and 1¾ inches respectively. The horizontal distance, measured along the ground line, between the centre of A and B, is 2¼ inches, and between the centre of B and C 1 inch; C is to the right of B. Find the traces of the inclined plane tangent to all three spheres and mark the projections of the tangent points. Check the accuracy of your work.

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING

First Year

SOLID GEOMETRY AND MENSURATION

1. If a straight line is perpendicular to each of two intersecting straight lines at their point of intersection, it is also perpendicular to the plane in which they lie.

2. If two straight lines neither intersect nor are parallel, then (1) there is one straight line perpendicular to both of them; (2) this common perpendicular is the shortest distance between the given lines.

3. Prove that there cannot be more than five regular polyhedra, and name them.

4. Define a *Lune*, and find its area, and hence deduce the area of a spherical triangle ABC.
What is *Spherical Excess?*

5. The length of each edge of a regular tetrahedron being a, show that (1) the whole surface $= \sqrt{3}\, a^2$, (2) the volume $= \frac{\sqrt{2}}{12} a^3$..

6. A rifle shell has the shape of a cylinder surmounted by a hemispherical cap. The total length of the shell is four times its diameter. Compare the curved surfaces and also the volumes of the cylindrical and spherical portions.

7. Supposing the Earth to be a sphere of diameter 7926 miles, find the length of the Arctic Circle (lat. 66° 30′) correct to four significant figures. Find also the area of the zone between latitudes 60° and 65°.

(over)

8. Prove that the volume of a spherical shell is equal to that of the frustum of a cone whose height is four times the thickness of the shell, and the radii of whose bases are the outer and inner radii of the shell.

9. A circle of radius 5 cm. revolves about a line 25 cm. from the centre of the circle.

(1) Find the surface area of the solid ring so generated.

(2) If the ring is made of copper of specific gravity 8.88, find the weight of the solid ring in kilograms.

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING

First Year

DIFFERENTIAL CALCULUS

1. Find from first principles the derivative of x^3+5 and of $\sin\theta$.

2. Differentiate the following:

(1) $\dfrac{1}{\sqrt{x^3}}$; (2) $5(2x^2-5)^3$; (3) $\dfrac{x-1}{x^2+1}$

(4) $\tan x$ (5) $\tan^{-1}x$.

3. Integrate:

(1) $\displaystyle\int\frac{3dx}{x^3}$; (2) $\displaystyle\int\frac{dx}{(1-x)^2}$; (3) $\displaystyle\int\frac{(x+a)dx}{(x^2+2ax)^5}$

(4) $\displaystyle\int\sec^2 4x dx$; (5) $\displaystyle\int\frac{dx}{5x^2+8}$.

4. Water is pouring steadily at the rate of 3 cubic feet per minute into a conical reservoir whose vertical angle is 60°. Find the rate at which the height of the water is rising in the reservoir when the height is 7 inches.

5. A window is in the form of a rectangle surmounted by an equilateral triangle. If the perimeter of the window is to be 15 feet, find its dimensions in order that it may admit the maximum amount of light.

6. Find the area included between the curve $y^2=16x$ and the straight line $y=x$.

7. Given $3y=x^3-9x^2+24x$, draw part of the graph, indicating maxima and minima points and points of inflection.

(over)

8. (*a*) Reduce 2.4145 to a continued fraction and find the first three convergents. What percentage is the error in the last.

(*b*) What is the chance of being dealt five cards, all red, from an ordinary whist pack of 52 cards?

(*c*) Reduce $\dfrac{2x^2+3}{(x-1)^2\,(x+1)\,(x^2+2x+3)}$ to partial fractions.

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ENGINEERING

First Year

PRACTICAL CHEMISTRY A

1. Find gravimetrically the weight of iron in the solution given you.

2. Standardize the acid solution (it is approximately normal tenth) and express the strength in normality and in grams HCl per litre.

3. Assuming the purity of the solution given you in question 1, what percentage accuracy should you obtain in the final result?

N.B.—Laboratory note books are to be handed in with this paper.

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ENGINEERING

First Year

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UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

First Year

PHYSICS

First Term

1. Distinguish between statics and dynamics. Explain terms: force, resultant, resolved part.

If two intersecting forces of 5 pounds and 8 pounds have a resultant of $\sqrt{129}$ pounds, find the angle between the two forces.

2. Explain fully what is meant by the triangle of forces and prove Lami's theorem.

Two weights support each other on two smooth inclined planes of same height, the weights being connected by a string passing over a smooth pulley at the junction of the planes. If the angles of the planes are 45° and 60° and the weight on the first plane is 50 pounds, find the other weight and the tension of the string.

3. What is meant by the moment of a force? Prove that if two forces intersect the algebraic sum of their moments about any point in their plane is equal to the moment of their resultant about the same point.

A sphere of radius 8 inches and weight 15 pounds, rests on a smooth plane inclined to the horizontal at an angle of 60° to which it is fastened by a string attached to its surface. If the tension of the string is equal to weight of the sphere, find the length of the string.

4. What are the two conditions for equilibrium of any number of forces acting in a plane?

Explain what is meant by a couple. Prove that the moment of a couple is the same about all points in its plane.

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING

First Year

PHYSICS

Second Term

1. Explain the terms, mechanical advantage, coefficient of friction, angle of friction, differential pulley.

A mass of 25 pounds rests on a rough plane inclined to the horizon at angle of 45°. What force applied parallel to the plane will be required to pull the body up the plane if the angle of friction for the plane is 30°?

2. Define the terms, poundal, acceleration, momentum, kinetic energy.

A stone of 45 pounds falls from rest through a distance of 36 feet and strikes the earth. It penetrates the earth a distance of 2 feet. Find the average pressure of the earth against the stone.

3. A force of 25 pounds acts for 5 minutes on a mass of 15 pounds initially at rest. What force will now be required to bring the mass to rest in 2 minutes?

4. A train is travelling at the rate of 30 miles per hour round a curve of radius 900 feet. Find at what angle the roadbed must be banked in order that the total thrust must be perpendicular to the roadbed.

5. Prove that a simple pendulum swinging in a small arc performs Simple Harmonic Motion.

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

First Year

SURVEYING

NOTE—Answer *eight* questions, which must include at least three problems.

1. Define: Surveying, Plane Surveying, Geodetic Surveying, Magnetic Bearing, True Bearing, Declination of the Needle, Isogonic Line, Agonic Line.

2. A steel tape is 100 ft. long at 70° F. What is the error in feet per tape length is the tape is used when the temperature is —20° F.?
Coef. of expansion for steel 0.0000063 per degree F.

3. An old map shows the bearing of a certain line to be N. $43\frac{3}{4}°$ W. In 1919, when the declination is 12° E., the bearing of the line is found to be N. $44\frac{1}{4}°$ W. If all declinations are increasing at the rate of 3 minutes per year, in what year was the map probably made?

4. Define: Line of Sight, Axes of the Level Bubble, Level Surface, Horizontal Line, and explain the purpose of the eye-piece in the telescope.

5. A line is prolonged one-half mile with a transit, using 300 ft. sights. The instrument is afterward tested and it is found that the line of sight is not perpendicular to the horizontal axis, the amount of the error being 0.01 ft. in 100 ft. How far is the final end of the line from its correct position?

6. If a transit is out of adjustment, explain how you would use it without adjusting and still avoid errors due to non-adjustment.

7. Name some of the common errors and mistakes which occur in transit work.

(over)

8. State the adjustments of the Wye Level in the order in which they should be made.

9. Into what two general classes are levelling rods divided? Name and describe some rods in each class.

10. A Dumpy Level was tested by the "Peg Method" as follows:

	Inst. at A	Inst. at B.
Rod on A,	4.863	2.775
Rod on B,	7.482	5.001

Which way should the cross hair be moved and how much to give a horizontal line of sight?

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ENGINEERING

First Year

SURVEYING

1. Name three ways in which the angles of a closed traverse may be measured with the method of checking each.

2. In connection with the location of topographical features from the transit line state the geometric principles involved in the location of a point and of a line. Define ties, offsets, swing offsets, and range lines.

3. Describe two common methods of passing an obstacle on the transit line and give their relative advantages.

4. Derive the fundamental formula for distance with the stadia and the formulas for horizontal and vertical distance with an inclined line of sight.

5. Western elongation of Polaris occurred at the 90th meridian April 15th, 1915, at 5h 52m and on May 1st at 4h 49m. Assuming that these values increase one-third of a minute a year find the central standard time of western elongation at Winnipeg on April 26th, 1920. Longitude 97° 08′ 10″ W.

6. Assuming $\cot^2 \frac{1}{2} Z = \frac{\sin (s - \text{L}) \sin (s - h)}{\cos s \cos (s - p)}$, latitude 49° 53′ 50″ N., altitude of sun 46° 36′ at 3h 15m P.M.C.S.T., April 28, 1920. Horizontal angle from traverse line to sun 108° 36′ Right. Find the bearing of the traverse line.

(over)

7. Make up a set of cross-section notes for road work which shall be consistent with the following data.

Grade elevation station 10 = 108.46. Rate of grade +2.5. Base 20 ft. Slope 1½ to 1. Station 10+00 to be a level section. Sta. 11+00 a three level section, sta. 12+00 a five level section and sta. 13+00 an irregular section.

8. Find the volume in cubic yards between sta. 10+00 and sta. 12+00 in the foregoing problem by the Average End Area Formula.

9. Explain the method of "Shooting In" a grade line.

10. State eight chief characteristics of contours.

Answer *eight* questions which must include Nos. 5, 6, and 8.

Note—Candidates will be provided with mathematical tables and will be permitted to use K. and E. Solar Ephemeris.

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

Second Year

CALCULUS

1. From first principles show that the derivative of ax^n with respect to x is nax^{n-1}.

2. Find $\frac{dy}{dx}$ in each of the following cases:

(*a*) $y = \frac{1}{\sqrt{x^3}}$

(*b*) $y = \frac{3a^x}{\cos^4 x}$

(*c*) $y = \log x^2 \tan^{-1} x$.

(*d*) $e^x \sec^2 y + a^{\sin y} = 6$.

3. A tank is in the form of an inverted square pyramid 12 feet in height. If the base of the pyramid is 10 feet square find how fast the water is running out when the surface of the water is 9 feet below the top and is falling at the rate of 2 inches per minute.

4. A sheet of tin 30 inches square has equal squares cut from each corner. The rectangular projections are then turned up to form an open box with square base and rectangular vertical sides. Find the side of the square that must be cut out from each corner in order that the box may have the greatest possible volume.

5. (*a*) Explain how to find the formula for the length of an arc of a polar curve.
(*b*) Find the entire length of the curve $\rho = a(1 - \sin\theta)$.

6. Find the volume obtained by revolving one arch of the curve $y = \sin x$ about the x-axis.

7. Find the area bounded by one loop of the curve $\rho = 10 \cos 2\theta$.

(over)

8. Integrate:

(a) $\int \frac{(x+a)dx}{x^2+2ax}$

(b) $\int e^{-x^2} x\,dx$

(c) $\int \frac{dx}{\sqrt{16-9x^2}}$

(d) $\int \frac{dx}{\cos^2(3x-2)}$

(e) $\int \cos 3x \cos 5x\,dx$

(f) $\int \frac{dx}{2x^2+5x-3}$

(g) $\int \frac{2x+5}{3x\sqrt{2x-3}}dx$

UNIVERSITY OF MANITOBA

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ENGINEERING

Second Year

CALCULUS

1. Find (*a*) $\int \frac{dt}{t^2(t^2+9)^{\frac{3}{2}}}$, (*b*) $\int x^2 \sin 2x dx$.

2. Find the area outside $\rho = a(1+\cos\theta)$ and inside $\rho = 3a\cos\theta$.

3. Obtain the volume removed when a circular hole 10 inches in diameter is bored centrally through a right circular cylinder 10 inches in diameter, the axis of the hole being perpendicular to the axis of the cylinder.

4. (*a*) Develop the formula $R = \left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}} \div \frac{d^2y}{dx^2}$ for the radius of curvature of a curve at any point, and *write down* the coordinates of the centre of curvature.

(*b*) Find the radius of curvature of the parabola $y^2 = 4x$ at the end of the latus rectum and obtain the equation of the evolute of this parabola.

5. Develop the expansion of $f(x)$ as a series in ascending powers of x, and by means of it expand $\cos x$ in this form.

6. (*a*) If $z = f(x, y)$ *write down* the total differential of z with respect to x and y; thence if $f(x, y) = 0$ show that $\frac{dy}{dx} = -\frac{\delta f}{\delta x} \div \frac{\delta f}{\delta y}$.

(*b*) By means of (*a*) find the equation of the tangent to the hyperbola $\frac{x^2}{8} - \frac{y^2}{1} = 1$ at the point $(4, -1)$.

UNIVERSITY OF MANITOBA

December Examinations, 1919

ENGINEERING

Second Year

ARTS

Third Year

SPHERICAL TRIGONOMETRY

1. Define "spherical triangle." Name its parts and show how these are measured.

2. Define "polar triangles." In two polar triangles each angle of the one is the supplement of the side opposite to it in the other. Prove.

3. State "Napier's Rules of Circular Parts."
Solve: $C = 90°$; $a = 44° 30'$; $b = 71° 40'$.

4. Obtain the formula $\cos a = \cos b \cos c + \sin b \sin c \cos A$.
Derive $\cos C$ from $\cos c$ by means of the polar triangle.

5. Derive one of the formulae:

$$\text{Tan } \tfrac{1}{2}(A+B) = \frac{\cos \tfrac{1}{2}(a-b)}{\cos \tfrac{1}{2}(a+b)} \cot \tfrac{1}{2} C.$$

$$\text{Tan } \tfrac{1}{2}(A-B) = \frac{\sin \tfrac{1}{2}(a-b)}{\sin \tfrac{1}{2}(a+b)} \cot \tfrac{1}{2} C.$$

6. Use the sine rule and the formulae of question 5 to solve: $a = 64° 24'$; $b = 42° 30'$; $C = 58° 40'$.

7. Find the area of a spherical triangle.

8. On a sphere of 30 yards radius, a spherical triangle is described where $A = 93° 59' 53''$, $B = 48° 21' 29''$, and $C = 58° 40'$. Find the area of the triangle.

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ENGINEERING

Second Year

KINEMATICS OF MACHINES

(No. 7 and only *five* other questions to be attempted).

1. Define Mechanism; Machine; Instantaneous Centre; Centrode; Plane-Motion; Speed; Velocity; Acceleration.

2. Three bodies have plane motion relatively to each other. Prove that all the instantaneous centres for any instant lie in one straight line.

3. Define Pitch Circle; Pitch Point; Base Circle; Circumferential Pitch; Diametral Pitch.

4. What is the fundamental law of Gearing, and show that this is satisfied if the normal to the common tangent of two teeth in contact passes through the pitch point.

5. By sketches show how Involute and Cycloidal Tooth Profiles satisfy the conditions in Question 4.

6. What are the common motions transmitted by cams. Show clearly how to obtain a cam profile that will transmit a uniform acceleration assuming point contact, without offset. (Elementary cam).

7. On the attached white print (1) tabulate the various instantaneous centres; (2) Locate on the drawing each instantaneous centre; (3) Obtain the relative velocities of the points "j" and "k" at the position shown, noting clearly the difference between speed and velocity. (Close accuracy not essential. Clearly indicate all procedure).

8. Design and sketch a pantagraph to give an enlargement of 3 to 2. Show how relative dimensions are arrived at.

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ENGINEERING

Second Year

MECHANICS OF MACHINES

(Attempt No. 7 and only five other questions.)

1. A long vertical bar is suspended by means of a loosely fitting washer which bears on a fixed point "a" inches and "b" inches from the far and near sides of the bar. (Such that $a-b=$ dia. bar). If the washer touches the bar at points "N" and "M" and if NM is at an angle θ to the axis of the bar, show that support is insured (non-slipping occurs) if $\frac{NM \cos \theta}{a+b}$ is less than the coefficient of friction.

(NM would be the diameter of the washer were it infinitely thin.)

By means of sketches, show how the above principle could be used in the design of an automobile jack to replace the usual lifting and holding ratchets.

2. Given the indicator card and weights of the reciprocating parts and connecting rod of a horizontal, 4 stroke cycle gasoline engine, show clearly with sketches, the method you would use in obtaining the Torque curve of the engine. Plot approximate average torque on same base.

What difference would be made if the engine were vertical instead of horizontal?

Neglect frictional effects in each case.

Plot a curve showing approximate speed fluctuation you would expect.

3. Derive a graphical method for obtaining the useful turning effort at any crank angle, given the available pressure on the cross head and length of connecting rod and stroke, neglecting friction.

(over)

4. Enumerate Newton's Law of Motion and define Mechanism, Available Pressure, Machine, Coefficient of Friction, Friction Circle.

5. Given the Torque Curve of an engine, show by sketches the advantages gained by coupling similar engines to the same crank shaft at different crank angles (apart from the additional horse-power resulting).
What effect would it have on the flywheel effort required, for equal speed fluctuation?

6. Show clearly the function of the flywheel and how it differs from that of the governor.
Given the permissible speed variation of a flywheel, and the Torque Curve with average Torque shown (as in question 2), obtain an expression for the weight of the flywheel.

7. Solve the problem contained in the attached white Print (clearness of method rather than mathematical accuracy will be considered).

8. Show the method of obtaining the reaction between a pair of gears in mesh, taking into account friction between teeth (assumed involute). State clearly all assumptions made.

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ENGINEERING

Second Year

DESCRIPTIVE GEOMETRY

1. Make a classification of lines. Give examples.

2. Make a classification of surfaces. Give examples.

3. The vertical projection of a point on the surface of cone being given, find its horizontal projection. Pass a plane tangent to the cone through the given point on the surface.

4. A right cylinder with a circular base stands on the horizontal plane with its axis vertical. The cylinder is cut by an oblique plane. Find the line of intersection. Eight points on the curve of intersection will be sufficient.

5. Find the traces of plane tangent to a sphere at a given point on the surface of the sphere.

6. Find the curve of intersection of any oblique cone by an oblique plane. Four points on the curve of intersection will be sufficient.

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ENGINEERING

Second Year

DESCRIPTIVE GEOMETRY

1. State the general method of finding the intersection of any two surfaces. Find the line of intersection of two cylindrical pipes whose axes intersect at a right angle. Explain the construction.

2. Show and explain the general method of finding the development of the surfaces of the two pipes in Question 1.

3. Explain the terms used in perspective drawing, and show how to draw the perspective of a cone.

4. Explain the difference between parallel perspective and angular perspective. Illustrate by drawing the perspectives of a rectangular block of wood.

5. Construct the perspective of the shadow of the rectangular block in Question 4 and explain fully how the perspectives of shadows of objects are found.

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ENGINEERING

Second Year

ANALYTICAL MECHANICS

Note—Candidates shall omit *one* of the problems: 1 (*b*), 3, or 7.

1. (*a*) A body moves in a straight line under the action of an attractive force which varies directly as the distance. Show that the motion is oscillatory, and find the period of a vibration.

(*b*) A 20-ton freight car moving with a speed of $2\frac{1}{2}$ miles per hour strikes a bumping post, and the spring in the draft rigging is compressed 3 inches. Find the strength of the spring. [A 10,000-lb. spring is such that a weight of 10,000 lbs. resting upon it compresses it one inch.]

2. (*a*) Find the period of vibration of the simple circular pendulum.

(*b*) A second's pendulum loses 4 seconds per day when taken to the bottom of a mine. Find approximately the depth of the mine.

3. A 9.2″ howitzer, with a muzzle velocity of 1500 feet per second is fired at a range of 13,000 yards. Find the angle of elevation of the gun. Is more than one elevation possible? How high does the shell rise?

4. A circle of 2″ radius touches internally another circle of 3″ radius. Find by integration, using polar co-ordinates, the centre of gravity of the area enclosed between the two circles.

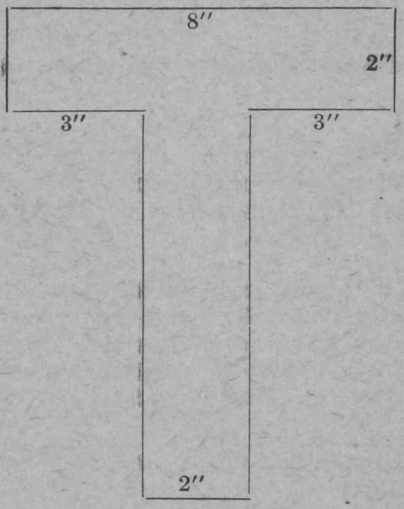
(over)

5. (*a*) Show that the moment of inertia of a plane area about a w-axis inclined at an angle α to the positive x-axis is given by $I_w = I_x \cos^2\alpha - i \sin 2\alpha + I_y \sin^2\alpha$.

Show that the moment of inertia is a maximum when

$$\sin 2\alpha = \frac{2i}{-\sqrt{4i^2+(I_y-I_x)^2}} \quad \text{and} \quad \cos 2\alpha = \frac{I_y - I_x}{-\sqrt{4i^2+(I_y-I_x)^2}}.$$

(*b*) The cross section of a T-beam is given in the accompanying diagram. Find the principal axes of the cross-section.



6. (*a*) Show that for any plane area immersed in a liquid the depth of the centre of pressure below the free surface of the liquid is given by the relation $\bar{\bar{x}} = \frac{I'_y}{\bar{x}A}$.

(*b*) The end of a circular water main 1 foot in diameter is closed by a temporary bulkhead. Find the centre of pressure on the end of the main if the surface of the water in the reservoir is 249′ above the top of the water main.

7. A flexible wire weighing $\frac{1}{3}$ lb. per foot is supported by two posts 200 feet apart. The horizontal pull on the wire is 2000 pounds. Find the sag in the wire.

UNIVERSITY OF MANITOBA

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ENGINEERING

Second Year

PHYSICS

First Term

1. Name and define the three magnetic elements of the earth's magnetism.

Prove that when a magnet is suspended in a megnetic field and oscillates it performs simple harmonic motion.

2. Explain neutral point in magnetic field.

Show clearly how to determine the magnetic moment of a magnet by the method of neutral points when the magnet is in the magnetic meridian, with its north end pointing south.

3. Describe the construction and working principles of *either* the Wimshurst influence machine *or* the Kelvin electrostatic voltmeter.

4. There are three condensers made as follows: (*a*) Ten plates each 15 cms. square and .2 cm. apart in air, (*b*) 2 plates each 12 cms. square and .5 cms. apart in oil whose S.I.C. is 3.6, (*c*) 4 plates each 8 cms. square and .4 cms. apart in liquid whose S.I.C. is 2.5. Find total capacity of these three condensers (1) when arranged in series and (2) in parallel.

UNIVERSITY OF MANITOBA

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ENGINEERING

Second Year

PHYSICS

Second Term

1. Explain the difference both in construction and in principle between the moving-magnet type and the moving-coil type of galvanometer. What factors determine the sensitiveness of a galvanometer?

2. If you have a solenoid 50 cms. long and consisting of 35 turns of wire and you pass a current of 5 amperes through it, find the intensity of the magnetic field produced inside the solenoid. Prove the formula which you use.

3. Explain the terms, permeability, electrolysis, self-induction, unit current, hysteresis. Write a detailed note on the construction, action and care of accumulators.

4. An electric circuit consists of 5 cells, each of 1.5 volts, in series with a rheostat of 18 ohms and a galvanometer of 12 ohms, the galvanometer being shunted with a coil of 6 ohms resistance. Find (1) total current in circuit, (2) current through galvanometer, (3) drop of potential across the rheostat.

5. What is refraction of light? State the laws of refraction.

Show clearly by use of a diagram how and where an image of an object placed in front of a concave spherical mirror is formed by that mirror.

UNIVERSITY OF MANITOBA

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ENGINEERING

Second Year

SURVEYING

1. Explain the Double Meridian Distance Method of finding the area of a field from survey notes. Show the different steps in the computation. Give rules for finding D.M.D.s., rule for distribution of errors, and formula for error of closure.

2. Make up a set of cross-section notes for earthwork passing from cut to fill.

Base in cut = 20 ft. Base in fill = 14 ft.
Slope in cut = $1\frac{1}{2}$ to 1 Slope in fill = 3 to 1.
Rate of grade = +0.45.

3. Compute the volume between any two stations in the foregoing problem.

4. Derive the fundamental formula for distance with the stadia and the formulas for horizontal and vertical distance with inclined line of sight.

5. State the Three Point Problem as applied to plane table work and describe *one* of the following solutions, giving rules where required. "Triangle of Error," "Bessell's," Canadian Engineer.

6. Given the following data. Find the elevation of the station occupied by the plane table:

Sta.	Distance	Elevation	Vert. Ang.
A	8648	1478.64	+4°54′
B	5865	1578.89	+8°10′
C	7480	436.82	−2°18′

Assume correction for curvature and refraction as $0.02k^2$ where k = distance in thousands of feet.

(over)

7. Describe the sextant and prove that the angle passed over by the Index Arm equals one-half the angle subtended at the eye.

8. Explain how you would obtain the altitude of the sun with the sextant.

NOTE—Mathematical tables will be provided.

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ENGINEERING

Second Year

SURVEYING

Note—Mathematical tables will be supplied and candidates will be permitted to use K. and E. Solar Ephemeris.

1. Explain the method of taking an observation on the sun for meridian with the Solar Attachment.

2. Compute the declination setting for use with the solar for an observation at 9h 45m A.M., C.S.T., April 28, 1920.

3. Draw a diagram illustrating the positions of base lines, principal meridians, correction lines and the manner of numbering townships and ranges in the Dominion Land Survey.

4. What township adjoins the 28th correction line on the north?

5. Give the distinguishing characteristics of the different systems of survey, and state approximately where each is in effect.

6. Define "Azimuth" and "Bearing" as used in the D.L.S. and explain what must be specified in order that the direction of a line may be defined by its azimuth or bearing.

7. For what purposes are traverses run in the D.L.S.? Do traverses ever constitute boundaries? What constitutes the boundary of land abutting on a navigable river?

8. Draw a diagram and deduce the exact and approximate formulas for the elements of a circular curve.

(over)

9. Given a 4° 30′ curve having a P.I. at Sta. 106+34.8 and I=36° 48′. Find all notes to run the curve by deflection angles.

10. Explain the method of laying out a simple circular curve by offsets from the tangent.

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ENGINEERING

Second Year

MATERIALS OF CONSTRUCTION

1. What raw materials are used in the production of pig iron? What are their principal constituents? Indicate in a general way the interchanges between these constituents which take place in the blast furnace. What products of the blast furnace are of economic value?

2. Describe the crucible process of making steel. What kind of steel does it produce and what are its principal uses?

3. Describe the process for making wrought iron and compare briefly the structure and principal properties of wrought iron and steel.

4. Discuss the following: Malleable castings; annealing; tempering; hardening.

5. Write a note on the influences of carbon, phosphorus, and sulphur in steel.

6. Describe briefly the acid Bessemer process for making steel. What are the chief modifications in the Basic process, and why are they employed?

7. Outline the process of producing rails from steel ingots, with special reference to *segregation*, *piping*, and *temperature of working*.

8. To what treatment would you submit a bar of high carbon steel in order to obtain:
(*a*) the greatest possible degree of hardness.
(*b*) a combination of hardness and toughness.
(*c*) to make it suitable for a cold chisel.

9. Write a note on the eutectic theory, with reference to the cooling of steel after solidification.

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ENGINEERING

Second Year

MATERIALS OF CONSTRUCTION

1. Write a note on the history of high speed tool steels. Give a typical example of their composition.

2. Mention some of the principal alloys used in the construction of machines, and state for what purposes they are used.

3. Describe the process of manufacturing Portland Cement. Mention the principal tests which the Engineer applies to cement, stating the relative importance of each.

4. Discuss the principles underlying the proportioning of the materials used in making concrete. State the arguments in favour of the surface area method.

5. What precautions should be taken in:

(*a*) pouring concrete in freezing weather;

(*b*) mixing and placing concrete which will be exposed to the action of alkali solutions.

6. Mention the principal points to be considered in securing first class masonry.

7. What are the chief agencies which cause decay in timber? Outline the chief processes used for preserving timber. How would you proceed to determine if it is economical to treat railway ties with a preservative compound?

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ENGINEERING

Second and Third Years

GRAPHICAL STATICS

1. Find graphically the centre of gravity of the section shown in Figure 1. The section is to be reproduced exactly from the blueprint.

2. Figure 2 is a cantilever truss loaded as shown. Using graphical methods,

(1) find the reactions;

(2) find the stresses in the members.

3. (*a*) Prove that the funicular polygon becomes the Bending Moment diagram for a beam carrying concentrated loads.

(*b*) Prove that the Bending Moment diagram for a beam uniformly loaded is a parabola.

4. The truss shown in Figure 3 carries a load of 20,000 lbs. as shown. Assuming the right end to rest on rollers, find the stresses in all the members. Use only graphical methods.

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ENGINEERING

Second Year

DRAWING (PRACTICAL)

Note—Marks will be assigned for neatness, accuracy and general appearance.

1. Draw the perspective of a wooden box, without top, to scale, the box is 20 inches long, 12 inches wide, 6 inches deep, with walls and bottom 1 inch thick.

2. Draw the perspective of a flight of four steps as if made of solid concrete; height of step 7 inches, tread 10 inches, length 4 feet. Use angular perspective for this problem.

3. Find the intersection of a cone and a cylinder.

Note—The model submitted is to be measured and drawn to suitable scale.

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ENGINEERING

Third Year—Civil

ENGINEERING GEOLOGY

1. Define: *Atmosphere, Lithosphere, Hydrosphere, Hydration, primary and secondary* (as applied to minerals).

2. Name and define the crystal systems.

3. Explain the classification of the feldspars and describe their most noticeable characteristics.

4. Describe the principal micas as to lustre, crystallization, hardness, colour and cleavage.

5. What effects have sulphide minerals on building-stones?

6. Describe the chief ore of (1) iron, (2) copper and (3) lead.

7. Describe briefly the principal forms of igneous intrusion.

8. Discuss the subject of texture in igneous rocks.

9. Give a brief classification of igneous rocks for field use.

10. Tell what you know about syenite and its relation to other rocks.

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ENGINEERING

Third Year—Civil

GEOLOGY

1. To what classes of rocks do the following belong: Shale, Soapstone, Granite, Gneiss, Marble?

2. Describe the properties and practical uses of the material mentioned in No. 1.

3. Discuss the relation of rock-folds to engineering operations.

4. Define *Weathering, Contact Metamorphism, Regional Metamorphism, Dolomitization.*

5. Explain the meandering habit in streams.

6. What are the requirements of a safe dam foundation?

7. Describe the raw materials and manufacture of Portland Cement.

8. In a gas and petroleum region, what would you understand by the terms: *pool, sands, well-pressure, asphaltic base, structure?*"

9. Explain the qualities of good road-materials, and name what you consider one of the best.

10. What are *Ore, Gangue, Replacement Deposits, Crustification, Magmatic waters?*

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ENGINEERING

Third Year

HYDRAULICS

1. Prove that the difference in pressure between different points in a liquid is equal to the weight of a cubic unit of the liquid times the vertical distance between the two points.
What does this become if one point lies in the surface?

2. Find the total pressure on a vertical rectangular sluice gate 6 ft. wide by 10 ft. deep, the head on its upper edge being 20 ft.

3. What should be the thickness of the wall of a 60-inch steel pipe under a head of 230 ft., assuming a maximum fiber stress of 15,000 lbs. per square inch?

4. Show that "In steady flow, without friction, the sum of velocity head, pressure head, and potential head is a constant quantity for any particle throughout its course." (Bernoulli's Theorem.)

5. In order to maintain a discharge of 1.20 cubic feet per second through a 6″ pipe discharging into the air, it is found necessary to keep a pressure of 36 lbs. per square inch in the pipe at the inlet end, which is 8 ft. above the outlet. What is the loss of head in the pipe?

6. Compute the discharge in twenty-four hours from a standard 2-inch circular orifice under a head of 6 ft. $c = 0.61$.

7. State Francis' Formulae for weirs.

8. A jet of water is discharged through a nozzle at a point 200 ft. below the water level at intake. The jet is 4 inches in diameter, and the velocity coef. of the nozzle is 0.90.
If the pipe line is 12 inches in diameter and 500 ft. long, what is the pressure at the base of the nozzle?

UNIVERSITY OF MANITOBA

April Examinations, 1920

ENGINEERING AND ARCHITECTURE

Third Year

STRENGTH OF MATERIALS

(*Six* questions only to be attempted.)

1. Obtain an expression for the resilience of a rod, under axial load, defining the quantities involved.

Two bars, one of brass, and one of steel, each 2 inches wide, ½-inch thick and 20 inches long are placed side by side to form a composite bar 2 in. x 1 in. x 20 in. long. Their ends are firmly connected and the bar is subjected to a pull of 20,000 lbs. so that the bars stretch equally. Find the load carried by the brass and by the steel, and the work stored in each. E for brass $= 12 \times 10^6$ lbs. per sq. in.; E for steel $= 30 \times 10^6$ lbs. per sq. in.

2. Deduce the formula $M = I \frac{f}{y}$ for the strength of beams, stating the assumptions on which it is based.

A steel I-beam, 10 inches deep has flanges 5 inches wide, and the thickness of metal throughout is 1 inch. This beam is 15 feet long and has a uniformly distributed load over the whole length together with a concentrated load at the centre equal to one-tenth of the total distributed load. If the allowable fibre stress is 16,000 lbs. per sq. in., calculate the safe loads.

3. Prove that the deflection at the centre of a uniform beam of length l supported at its ends and carrying w lbs. per unit length is $\frac{5}{384} \frac{wl^4}{EI}$

If the greatest allowable deflection for such a beam is 1-600 of its span, find the limiting ratio of depth to span, if the bending stress is limited to 16,000 lbs. per sq. in. and E $= 30 \times 10^6$ lbs. per sq. in.

(over)

4. Prove that in a bent beam the angle between the tangents at the ends of a given length is equal to the area of the B.M. diagram for that length $\div$ EI; show also that the B.M. at the centre of a beam fixed at its ends and carrying a concentrated load at its centre is one-half the value which it would have if the ends were free.

Draw the B.M. diagram for a beam 20 ft. long, fixed horizontally at its ends and carrying three loads of 10 tons each at points 4 ft., 10 ft., and 16 ft., respectively from one end.

5. Deduce from first principles the theorem of three moments for two successive spans of a continuous beam carrying a uniform load.

A beam ABCD rests on four supports A, B, C and D, at the same level. The ends are free and the beam is loaded uniformly over its entire length with 1 ton per foot. If AB = 30 ft., BC = 20 ft. and CD = 40 ft., determine the pressures on the supports and sketch the B.M. and S.F. diagrams.

6. What is meant by horizontal shear in a beam? Obtain a formula by the use of which the intensity of shearing stress at any point in the cross section of a beam can be calculated.

A timber stringer 6 in. x 16 in. rests on two supports 20 ft. apart and carries two concentrated loads of 16,000 lbs. each at a distance 2 ft. from each support. Find the greatest intensity of shearing stress along the fibre of the timber.

If the ultimate resistance to compression is 8000 lbs. per sq. in. and the resistance to shear along the fibre is 600 lbs. per sq. in., indicate the probable manner of failure as the load is increased.

7. State the nature of the stresses in a shaft subjected to a simple twisting moment T, and show that if f is the maximum stress produced, d the diameter of the shaft, G the coefficient of rigidity, and θ the angle of torsion per unit length.

$$T = \frac{\pi}{16} f d^3 = \frac{\pi G d^4 \theta}{32}.$$

A shaft 11 feet long transmits 100 H.P. at 140 R.P.M. Assuming a simple unvarying twisting moment, find the diameter if the total angle of torsion is not to exceed $\frac{2}{3}°$. Take $G = 10.5 \times 10^6$ lbs. per sq. in.

8. Prove Gordon's formula for the strength of columns and show how it is connected with the Rankine formula.

A vertical hollow steel tube with fixed ends is 20 ft. long, internal diameter 12 inches and carries a load of 500,000 lbs. Find the necessary thickness of metal allowing a factor of safety of 6. Take $f = 67{,}500$ lbs. per sq. in. for failure and the constant in Rankine's formula $= \frac{1}{36000}$.

What would the column carry if the ends were hinged?

9. State the conditions which govern the equilibrium of a retaining wall and determine the limiting values of the deviation of the centre of resistance from the middle point of the base.

A wall built of material weighing 125 lbs. per cu. ft. is 5 ft. wide at the top and 10 ft. wide at the base. It has one face vertical and retains water on this face level with the top of the wall. Find how high the wall may be if there is to be no tension at the water face.

10. Show how the principal stresses at any point in a stressed solid may be found, in magnitude and direction.

Find the magnitude and direction of the principal stresses at any point of a shaft, subjected to a twisting moment T and a bending moment M, and deduce the so-called equivalent bending moment.

Find the maximum compression in a shaft at a point when the shear stress is 4 tons per sq. in. and the compressive stress is 3 tons per sq. in.

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ENGINEERING

Third Year

RAILWAY ENGINEERING

Note—Candidates will be permitted to use Allen Curves and Tables.

1. Given $I = 28° 30'$, $D = 4°$, P.I. = Sta. $61+38.6$. Find the degree and the station of the B.C. of a new curve which shall end in a parallel tangent 12 ft. inside the old tangent and have the new E.C. directly opposite the old E.C.

2. Given a 6° curve compounded with a 10° curve, the P.I. at Sta. $48+21.4$, $I_6 = 26° 42'$, $I_{10} = 37° 24'$. It is desired to spiralize this curve using 180 ft. spirals. Find all notes to run the curve by deflection angles.

3. Given a turnout from standard gauge track, length of switch rail 16′, thickness at point $\frac{1}{4}''$, spread at heel $6\frac{1}{4}''$, a number 9 frog having a thickness at point of $\frac{1}{2}''$ and distance from theoretical point to toe 6′ 0″. Find the radius of the lead curve and the theoretical and actual leads.

4. Given the following set of cross-section notes, find the volume by Allen's Table XXX:

Base 14′, slope $1\frac{1}{2}$ to 1.

Sta.	L.	C.	R.
49+00	−8.4		−12.1
		−10.6	
	?		?
48+00	−6.3		−8.0
		−8.1	

(over)

47+00	−3.6		−4.3
		−7.0	
	?		?
46+00	−6.5		−1.0
		−2.8	
	?		?

5. A +2.5 per cent grade meets a +1.5 per cent grade at Sta. 64 whose elevation is 118 ft. The rate of change being 0.10 per station. Find the elevations of the stations of a vertical curve to connect the two grades.

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ENGINEERING AND ARCHITECTURE

Third Year—Civil

ARCHITECTURE

Fourth Year

REINFORCED CONCRETE

(Tables and Curves in Text Book may be used.)

1. Show clearly what is meant by horizontal shear, and prove that the intensities of the horizontal and vertical shears at any point in a plain concrete beam, are equal.

Discuss fully the subject of diagonal tension in concrete beams and the different methods of reinforcing against failure by diagonal tension.

2. Find the position of the neutral axis for rectangular concrete beams reinforced for tension only, stating the assumptions made.

Deduce the following formulae:

$$p = \frac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}$$

$$M_c = \tfrac{1}{2} f_c\, kjbd^2$$

$$f_c = \frac{2f_s p}{k}.$$

3. Find the position of the neutral axis and the moment of resistance of a reinforced concrete beam 8 inches wide, and 18 inches deep, proportioned so that the steel is stressed to 16,000 lbs. per sq. in. in tension and the concrete to 600 lbs. per sq. in. in compression, the centre line of the steel being 2 inches from the surface of the beam.

(over)

4. A T-beam of a reinforced concrete floor system is 26 inches deep over all, the stem is 12 inches wide and the floor slab is 4 inches thick. The beams are 20 ft. long and 7 ft. 6 in. on centres. The floor load is 150 lbs. per sq. ft. and the weight of concrete is 150 lbs. per cu. ft. Choosing suitable stresses for steel and concrete and making allowance for effective width of flange in accordance with standard specifications, determine the necessary reinforcement at the middle of the span, at the supports, considering the beam continuous; and for complete protection against diagonal tension. Make a sketch of the beam showing reinforcement details.

5. Write a note on the behaviour of reinforced concrete columns under test, when reinforced with:

(*a*) longitudinal rods.
(*b*) spiral reinforcement.
(*c*) combination of (*a*) and (*b*).

Show that for columns with vertical reinforcement only, the unit stress $f = f_c [1 + p(n-1)]$.

6. A circular column 2 ft. 6 'n. outside diameter is required to carry 500,000 lbs. Allowing a fire protection covering of 2 inches and assuming that the allowable stress in the concrete is 650 lbs. per sq. in., determine the amount of longitudinal and spiral reinforcement necessary.
Sketch the arrangement of longitudinal and spiral steel.

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ENGINEERING

Third Year—Electrical and Civil

THERMODYNAMICS

(Nos. 3 and 10 and only four others to be attempted.)

1. Define: Proximate Analysis, Bleeder Turbine, Prony Brake, Throttle Governing, Tandem Compound, Ratio of Expansion (Compound Engine), Automatic Governing, Inside Admission, Mixed Pressure Turbine, Card Factor. State use or sphere of operation of each.

2. Show, aided by sketches, the principle of the Hvid vaporizer. Assuming the general strength sufficient, what essential changes would you make to an ordinary Otto Cycle, 4-stroke oil engine in order to fit it with a Hvid vaporizer.

3. Samples of Coal and Fuel Oil show the following analysis by weight:

	Coal	Fuel Oil
C	73%	85%
H	4%	12%
O	8%	3%
Ash, etc.	15%	.....

Assuming perfect combustion, what would be in each case,

(*a*) the theoretical weights of air required?
(*b*) weights of resulting flue gas and ash.
(*c*) percentage by volume of CO_2 (from fuel analysis).

How do you account for the difference in (3)? Under working conditions which would show the greater percentage of CO_2? Does this mean necessarily a lower efficiency of combustion?

4. A plant consists of duplex feed pumps, boilers and a non-condensing engine. Coal has increased in price and good feed water become limited. Assuming ample cooling

(over)

water at low temperature to be available, sketch a piping system connecting your choice of Condenser Feed Water Heater and Economizer, etc., and state why the presence of each additional apparatus would assist in the general plant efficiency.

5. Sketch a wiring diagram for a Make and Break, also Jump Spark Ignition System. Tabulate the relative advantages and disadvantages of each.

6. Sketch exaggerated Indicator Cards to be expected from the working cylinder, also crank case of a two-stroke gasoline engine. Discuss fully.

7. Show clearly the difference between the classes of turbine in which
(*a*) the velocity is compounded;
(*b*) the pressure is compounded;
and name makes of turbine which are typical of each class.

8. Obtain an expression showing the theoretical Mean Effective Pressure in a steam cylinder, given the cut-off and initial and final pressures.

A double-acting engine, 12″x15″ stroke of 200 R.P.M. cut-off ¼, steam pressure 100 lb. gauge, back pressure 2 lb. absolute, has an indicator Card Factor of 80%. What is its I.H.P.?

9. Define Isothermal and Adiabatic Expansion.

If P_1, V_1, and T_1, and P_2, V_2, T_2, are points on an adiabatic expansion curve, obtain equations showing the relationships between the respective pressures and volumes and the corresponding temperatures.

10. In a Carnot Cycle using air, $P_1 = 1000$ lbs. per sq. ft.; $V_1 = 100$ cu. ft.; the pressure at the end of Isothermal expansion is $P_2 = 500$ lbs. per sq. ft; the condenser temperature T_2 is 200° F.

Find press at end of Adiab expansion, (P_3); and the external work done on all four paths.

11. Steam at 100 lbs. per sq. inch abs. passes into a Throttling Calorimeter where its pressure and temperature were observed to be 15 lbs. per sq. inch absolute and 243° F. respectively. What was the quality?

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ENGINEERING

Third Year—Civil

LEAST SQUARES

1. Obtain the equation of the probability curve in the form $y = ke^{-h^2x^2}$

2. The following observations are made on the quadrilateral ABCD:

Angle A = 67° 23′ 10″	Angle CDB = 65° 4′ 5″
Angle B = 121° 6′ 55″	Angle ADB = 51° 11′ 55″
Angle C = 55° 14′ 10″	Angle ABD = 61° 25′ 10″
Angle D = 116° 16′ 5″	Angle CBD = 59° 41° 55″

Use the method of least squares to determine the most probable values of the angles. Indicate what modification would have to be made if the angle C had not been observed.

3. The following measurements are found for a quantity: 149.1, 149.06, 148.93, 149.05, 148.89, 148.95, 149.01. Determine the probable error.

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ENGINEERING

Third Year—Electrical

MACHINE DESIGN

(*Six* questions only to be attempted.)

1. Show the analogy between the bursting stress in a circular shell under fluid pressure and that in a rotating ring (*e.g.*, the rim of a pulley neglecting the effect of spokes). State equations giving the unit stress in the material in each, tabulating all symbols used.

2. The overhung flywheels of an air compressor are 8 feet in diameter. One of them has a total wobble of ¼-inch. The rim is 10 inches deep radially and 5½ inches wide. Neglecting effect of hub and spokes, what is the bending moment, due to the wobble, at a speed of 100 R.P.M., assuming C. of G. of a half rim is at a radial distance of 28 inches. Cast iron weighs 450 lbs. per cubic foot.

3. Sketch a treble rivetted double butt strap joint having the outer rivets at double pitch. State equations giving the strength of the joint under five possible methods of failure. State the efficiency of each method compared with the unpunched plate.
Tabulate meaning of all symbols used. Assume double shear resistance to be twice that of single shear.

4. Given the Torsional and Bending Moments in a circular shaft. State equations giving the diameter of shaft required,
(*a*) When the moments act separately.
(*b*) When acting conjointly.

5. Discuss fully the strength of cylinder head bolts
(*a*) when the joint is "metal to metal" and the connected parts assumed incompressible;
(*b*) when an elastic gasket is used.
Why are the axles of freight cars usually tapered to a smaller section midway between the wheels?

(over)

6. Show by sketches the principle of the Michell (or Kingsbury) Thrust Bearing, and the object aimed at in its design.

7. Account for the "creep" in a leather or canvas belt, and hence for the divergence from the theoretical speed ratio between two pulleys connected by a belt under load.

8. It has been stated that the "Factor of Safety" should be called the "Factor of Uncertainty." Discuss fully and give reasons for the use of the Factor.

9. What are the advantages gained in the use of cast iron as a material for machine parts. Account for the presence of the various flaws found in cast iron.

Sketch a casting which would possess extreme shrinkage strains and show how such could be avoided,

(*a*) in the design;

(*b*) in the casting process.

10. The port of a jib crane secured at the foot only, is of cast iron with an I-section having flanges 2″x½″ and web 3″x½″.

What load, at a radius arm of 30 inches, could be carried if the maximum stress be limited to 9000 lbs. per square inch?

11. Sketch the cross section through the throat of a punching machine and indicate fully your method of obtaining the moment of Inertia and Section Modulus.

To what relative scale would you alter the dimensions for the machine to punch a plate requiring three times the effort?

12. A body of weight "W" and a linear velocity v is constrained by a force f to follow a curve whose radius of curvature is r. Show that its radial acceleration is $a = \frac{v^2}{r}$.

and also that $f = \frac{W \omega^2 r}{g}$ when g = acceleration due to gravity and *where* ω = its angular velocity.

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ENGINEERING

Fourth Year—Civil

GEODESY

1. Draw a diagram illustrating three special systems of triangulation and compare them with reference to cost and accuracy.

2. Name three things which govern the minimum elevation of each of two stations in order that they may be intervisible and explain the effect of each.

3. Draw a diagram and deduce the formula for effect of Curvature and Refraction in terms of the distance and the mean radius of the earth.

4. Given point A at elev. = 100 and point B 20 miles distant. Assuming that only the rotundity of the earth intervenes, what must be the elev. of B that it may be visible from A?

5. Describe the Eimbec Duplex Base Bar and explain the principle upon which its use depends.

6. Deduce the correction to be applied to the measured base to obtain its length at mean sea level.

7. What is "Spherical Excess" and how is it corrected for in different cases of adjustment of triangles?

8. Explain the use of the barometer in leveling; and define "Initial Error" and "Inertia Error."

9. Compare the "European" and U.S.G.S. precise levels.

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ENGINEERING

Fourth Year—Civil Engineering

HIGHWAY ENGINEERING

1. State the essentials of an ideal road or pavement.

2. Discuss the design, construction and maintenance of earth roads.

3. Discuss the following bituminous materials as directly used in highway engineering:
(*a*) Dust preventives.
(*b*) Carpeting mediums.
(*c*) Seal-coating materials.
(*d*) Bituminous cements.
(*e*) Bituminous fillers.
(*f*) Impregnating materials.

4. Outline the preliminary investigations necessary to design satisfactorily and economically highways.

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ENGINEERING

Fourth Year—Civils

ELEMENTS OF ELECTRICAL ENGINEERING

Answer *eight* questions.

1. Describe three types of electric resistances of a variable nature and discuss the characteristics of each type indicating its particular advantages.

2. Draw a diagram showing the connections for starting a shunt wound direct current motor.
Explain two essentials for properly starting such motors.

3. Compare the characteristics of the direct current series motor and the direct current shunt motor and designate what class of service each of these types of motors is specially suited.

4. Specify two methods of varying the speed of a direct current shunt motor and explain the advantages of each method.

5. Explain thoroughly the advantage of the use of alternating current as compared with direct current for the transmission of power for considerable distances.

6. Describe the construction of the Edison storage battery and compare this cell with a lead battery as to characteristics and operation.

7. Explain in detail the volt ampere characteristic of the lead-aluminum electrolytic cell and explain how this may be used as a rectifyer of alternating current.

8. What is Faraday's law of electro magnetic induction and indicate how this law applies to transformers and to direct current dynamos.

(over)

9. A direct current shunt motor gives an output of 7½ Horse Power and takes 100 amperes at 110 volts; what is the efficiency of this motor?

The above motor when running at zero load and normal speed takes 6 amperes from the line and 110 volts on the armature, the field amperes are 2.5, the armature resistance is 0.01 ohm; compute the power loss of this motor.

10. A motor is to be selected to operate a draw bridge. What types would you consider most desirable for this purpose?

(*a*) For direct current operation.

(*b*) For alternating current operation.

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ENGINEERING

Fourth Year—Civil

FRAMED STRUCTURES

(Carnegie hand books may be used.)

1. Prove that if a beam is loaded with concentrated loads, the maximum moment under any given load occurs when that load and the centre of gravity of all the loads on the beam are equidistant from the centre of the beam.

2. Prove that for a maximum shear in any panel of a bridge truss, carrying concentrated loads, the load on the panel must be equal to the load on the truss divided by the number of panels:

3. Design the central section of a plate girder 50 ft. long to carry 3000 lbs. per lineal foot. Available angles 6″x4″x⅝″. Use any available specifications.

4. Prove that the pitch of the flange rivets at any point in a plate girder is equal to the product of the value of one rivet into the depth of the girder divided by the shear at the point. Find the pitch of the rivets in the girder in Question 3 at a point 10 ft. from the end, using conventional values for size of rivets and allowable shearing and bearing values.

5. A member of a roof truss is 6 ft. long and is made up of two 3½″x3″x⅜″ angles with the longer legs back to back and ⅜″ apart. The member is connected by ⅞″ rivets.

What load will the member carry in tension? in compression?

6. A Pratt truss span consisting of 7 panels each 24 ft. long, is 30 ft. deep. Find the stresses in the members of the leeward truss due to the overturning moment of the wind on the train amounting to 300 lbs. per lin. ft. of train, considered as applied 12 ft. above the plane of

(over)

the lower laterals. The distance centre to centre of trusses is 18 ft.

7. A top chord section 30 ft. long consists of:

1 CP., 24″x½″.

2 top *L*'s, 3½″x3½″x⅜″.

2 webs, 18″x⅝″.

2 bottom *L*'s, 4″x4″x⅝″.

If it carries a compressive stress of 680,000 lbs. applied at the centre of the web, calculate the maximum fibre stress taking into account the weight of the member.

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ENGINEERING

Fourth Year—Civil

FRAMED STRUCTURES (PRACTICAL)

(Reference books may be used.)

1. A plate girder is made up as follows:

1 Web 66″x½″.
4 L^s. 6″x6″x½″.
2 C.P. 15x½.

Design a splice to develop the full section of the Web.

2. A through span has panels 26 feet 6 inches long. Design a stringer and connections of the stringers to the floor beam, using the Dominion Government "Heavy" loading. Weight of track 400 lbs. per lineal foot. Assume web of floor beam to be ⅜ in. thick.

3. Find the stresses in the members of the portal shown, and also the greatest BM. in the batter posts. Assume the posts to be fixed at the lower ends.

4. A pin is loaded as shown. Find its proper diameter.

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ENGINEERING

Fourth Year—Civil

WATER SUPPLY

1. Discuss the influences affecting stream flow and the general methods of obtaining the flow of streams.

2. In examining the ground water supply in any district, what data would you obtain in order to get a fair idea of the quantity and quality of ground water?

3. What were the reasons for the low rate of water consumption in Winnipeg when supplied by the old well system. How is the new system likely to affect the consumption?

4. Discuss "Examination of Water Supplies" with special reference to Collection of Samples, Chemical Analysis, its purpose and value; Bacterial Analysis, its purpose and value.

5. Into what three groups may the constructive features of a water supply system be divided?
State briefly the various subdivisions of these groups.

6. Discuss briefly the question of Storage, with reference to computation of amount, location of reservoirs, preparation of reservoir site, etc.

7. Describe the construction of a slow sand filter and give the biological explanation of the purification of water in sand filtration.

8. What are the general requirements for a distribution system?

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ENGINEERING

Fourth Year

RETAINING WALLS AND FOUNDATIONS

1. Define principal stresses. If the principal stresses are not of the same kind but their intensities the same, prove that the resultant will make an angle θ with the direction of the principal stress, and its intensity is equal to that of either principal stress.

2. Discuss the stability of trapezoidal retaining walls against:

(*a*) overturning;

(*b*) sliding;

(*c*) crushing.

Illustrate the graphical methods of finding the factors of safety.

3. A foundation is subjected to eccentric loading. Deduce formulae for finding the distribution of pressure upon the base of the foundation. Illustrate the equations by means of diagrams.

4. How are piles classified? State the advantages and disadvantages of each type.

5. A wooden pile is driven by a hammer weighing 1800 lbs. falling from a height of 30 feet. The average penetration for the last few blows is 2 inches. What will be the safe load according to the "Engineering News" formula, $S = \frac{2wh}{a+1}$?

6. Describe the strata underlying the City of Winnipeg. What precautions are necessary to secure good foundations?

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ENGINEERING

Fourth Year

SEWAGE DISPOSAL

1. (*a*) Name the three main types of sewage systems and write a short note on each.

(*b*) Give five advantages of the separate water carriage system, and five of the combined.

2. (*a*) State the four factors which govern the flow of liquid in a pipe.

(*b*) Deduce Chezy's formula, and explain the meaning of each factor.

3. (*a*) Compute the velocity of flow in a circular masonry conduit, 6 feet in diameter and running half full. Grade being 1 foot per 1000 feet.

(*b*) What is the discharge?

Given $C = \dfrac{41.6+\dfrac{.00281}{S}+\dfrac{1.811}{n}}{1+\left(41.6+\dfrac{.00281}{S}\right)\dfrac{n}{\sqrt{R}}}$ and $n=.015$.

4. A circular sewer has for 600 feet in length to discharge 8 cubic feet per second, then for 700 feet more has to discharge 10 cubic feet per second, and again for 700 feet, farther on 12 cubic feet per second. The total fall available is 5 feet.

What is the required diameter and fall of each section?

5. An open brick channel 4 feet wide at the bottom, with vertical sides, has a depth of water in floods of 4 feet and a slope of 1 in 700. It is intended to substitute

(over)

for it a circular sewer whose mean velocity full shall be about 4.5 feet per second. What should be the diameter and grade of the new circular sewer flowing full?

6. An egg-shaped sewer, 6 feet by 9 feet, has a slope of 8 feet per mile. What is its velocity and discharge flowing full, flowing two-thirds full depth, and one-third full depth?

7. (*a*) Name eight methods of treating sewage, and write a note on each.

(*b*) State the objects sought.

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ENGINEERING

Fourth Year

RAILWAY ECONOMICS

1. Discuss four causes modifying volume of revenue.

2. What is the unit of measurement for operating expenses? Why is the value of this unit increasing? Why are the "passenger mile" and "ton mile" used as units of tariff when they bear so little relation to cost of operation?

3. Discuss the effect of a change in the length of a line on revenue and expenses.

4. What is meant by "Compensation for Curvature"? Draw diagrams and explain the effect of uncompensated curvature occurring on ruling grades or grades nearly equal to ruling grade, and the effect of compensating this curvature.

5. Explain by use of diagrams the meaning of "Rise and Fall."

6. Give the classification of minor grades.

7. What are the three elements in the locomotive which determine its capacity to do work? Give the formula for tractive effort in each case and explain when each would limit the tractive effort of the locomotive.

8. Discuss "Ruling Grade."

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ENGINEERING

Fourth Year

Civil and Electrical

WATER-POWER DEVELOPMENT

(No. 3 and only *five* additional questions to be attempted)

1. A certain point on a stream has been decided on for a proposed Hydro-Electric Development. A hydrograph is available for a point some distance away on the same stream.

What would be your considerations in modifying this hydrograph to apply at the site to be developed?

2. What variables would affect the general relationship between precipitation and run-off per month throughout the year and also from year to year.

3. Assuming your own data for a proposed development for an A.C. supply, sketch the general layout you would suggest, indicating salient features of your design.

4. For the data in problem 3, outline the specification for Turbines and Governors.

5. Describe the various method of governing an Impulse Turbine, indicating how refinements of regulation are attained.

6. Compare the operations of the Woodward Governor and that of which the Lombard is typical. Show clearly the additional features to governing presented by the existence of a long pipe line, over the open flume type of setting.

(over)

7. Describe the various gate operating mechanisms in both large and small sizes for (1) Scroll Type Turbines; (2) Two double Francis Turbines on the one shaft, and in this case indicate clearly how simultaneous operation can be approximated when the governor is located at a distance from machines.

8. For what conditions are the various types, speeds, and settings of turbines in general peculiarly adapted. Sketch a velocity diagram for an inward, radial-flow turbine.

9. Sketch and describe the various types of dams and show how each is particularly adapted to varying conditions of cost (first and ultimate); height; with or without spillway; bad, ordinary, or good foundations; and presence or absence of penstock and gates.

10. What are the various forms of ice which affect plant operation. What are the modern methods of mitigating or eliminating such troubles.

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ELECTRICAL ENGINEERING

Fourth Year

ELECTRO CHEMISTRY

1. Describe two processes for the fixation of Atmospheric Nitrogen. What international interest is attached to these processes?

2. Electro-chemically what do these two expressions signify: $e = RT \log \frac{P_{H_2}}{pH}$ and $e = RT \log \frac{C_1}{C_2}$?

3. Give the construction, operation and use of:

(*a*) copper coulometer;
(*b*) dry cell;
(*c*) resistance furnace.

4. How does the theory of electrolytic dissociation apply to the corrosion of iron water pipes in Winnipeg?

5. Write a note on the electrolytic winning and refining of metals in aqueous solution.

6. What is a pyrometer, storage battery, Townsend cell?

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ELECTRICAL ENGINEERING

Fourth Year

HIGH TENSION TRANSMISSION

1. Derive either (*a*) the formula for the inductance in mil henrys per mile of one conductor of a transmission line, or (*b*) the capacity in microfarads per mile. (*c*) What is the inductance of each conductor of a 3-phase line 80 miles in length. The conductors are triangularly spaced 7 feet apart and consist of solid copper .4 inch in diameter. (*d*) What is the capacity per wire of the same line?

2. (*a*) If 20,000 K.W. at 60,000 volts, 3-phase 90 per cent. power factor is to be delivered over a line having a resistance of 27 ohms and a reactance of 25 ohms per wire, what will the voltage be at the generator end neglecting the effect of capacity? (*b*) What will the charging current be at full load if the capacity per wire is 1.2 microfarads, assumed to be concentrated at the centre of the line, and the frequency is 25 cycles?

3. What is meant by the "natural frequency" of a line and under what conditions is it necessary to give special consideration to this phenomenon of a transmission system?

4. (*a*) Explain what is meant by Corona Loss in a transmission system. (*b*) Compute the critical voltage and the power lost due to corona for a 3-phase line with the following constants: Length 100 miles. Conductors 0.3 inch diam. clean solid copper. Spacing 10 ft., triangular. Effective volts between conductors, 150,000. Frequency, 60 cycles. Barometric Pressure, 29 inches. Temperature, 65 degrees Fahr. Disruptive strength of air, 53.6 K.V. per inch, effective.

5. Describe briefly the process of manufacturing and testing porcelain insulators for high voltages.

6. Explain with the aid of a sketch how Inverse Time Current and Directional Relays would be applied to protect the feeders of a ring system of distribution.

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ELECTRICAL ENGINEERING

Fourth Year

ELECTRIC TRACTION

1. (*a*) What are the principal factors included in "train resistance?" (*b*) Explain how each factor is affected by the speed at which the train is running, and the weight of the train.

(*c*) Determine the tractive effort required to enable a train consisting of 4 motor cars and 2 trailers to climb a 3 per cent grade at a uniform rate of 12 miles per hour. The weight of the trucks per car is 8 tons, the weight of the motors and control equipment is 7 tons per car; the weight of the car body is 20 tons. Each car carries 75 passengers (average weight, 140 lbs.). Car cross-section = 90 sq. ft.

2. Discuss the suitability of the following types of motor for railway purposes: D.C. Shunt, D.C. Series, A.C. Series, A.C. Induction, A.C. Repulsion.

3. An 8 car train having 5 motor cars each equipped with two 200 horse power, 500 volt motors weighs 320 tons including passenger load. The characteristic curves of the motors are shown on the attached sheet. Plot the portion of the speed curve between 0 and 20 miles per hour for an initial acceleration of 2 miles per hour per second on a tangent level track. The cross-section of the car is 110 sq. ft., and the average speed during initial acceleration is 10 miles per hour.

4. Explain the functions of the following portions of the control equipment for an electric car or train: (*a*) Master Controller, (*b*) Magnetic Blow-out, (*c*) Limit Switch (*d*) Line Relay.

5. (*a*) Describe with diagramatic sketch one form of automatic air-brake equipment and explain the functions

(over)

of the various parts. (*b*) What is the shortest time in which a train running at 60 miles per hour on a straight level dry track can be brought to rest by the brakes?

6. Given the following data, determine the minimum length of a feeder with which it would be economical to use a booster for voltage regulation:

ρ = 10.5 ohms per mil-foot.
w = wt. of copper in lbs. per mil-foot = 0.00000303.
c_2 = 0.17 = cost of copper in dollars per pound.
c_3 = 0.006 = cost of generating one K.W.H. in dollars.
p_1 = 0.10 = combined rate of interest and depreciation on the cost of the booster.
p_2 = 0.06 = rate of interest on capital expended on copper.
h = 6000 = annual hours operation.
e = 50 = total boosted feeder drop in volts.

The cost of the booster may be expressed as $f+g\times$K.W. where $f=300$ dollars and $g=50$ dollars.

7. Discuss fully the causes of and principal remedies for electrolysis of underground pipes.

8. Give a list of the principal items of equipment and a diagram of connections for a substation to take A.C. at 11,000 volts, 3 phase, 60 cycles, and deliver D.C. at 550 volts for a section of an interurban railway. Substation capacity, 200 K.W.

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ENGINEERING

Fourth Year—Electrical

POWER PLANTS

(Eight questions only to be attempted.)

1. By means of sketches show clearly the principles and essential details of Jet and Surface Condensers. For what particular conditions is each suitable and what additional auxiliaries are required to obtain high vacua.

2. Classify the important scale forming impurities in boiler feed water, and the remedy in each case.

3. Discuss Closed, Open, and Live Steam Feed Water Heaters and Economizers, stating the objects aimed at by the use of each. By means of simple piping diagrams, show the methods of connection in an up-to-date power plant where economy in fuel and feed water is essential. What temperature range can be expected in each.

4. Describe the various systems of Central Heating, pointing out the conditions under which each would be a profitable undertaking.

5. Discuss the present wide use of the Centrifugal Pump especially in competition with the High Duty Pumping Engine.

6. Sketch the Pulsometer Pump, describing its principle and the uses for which it is peculiarly adapted.

7. Classify the common lubricants and state where each is suitable.
In a Compound Engine using superheated steam which is condensed and returned to the boiler, what oil would you recommend (*a*) for the H.P. cylinder, (*b*) the L.P. cylinder? Why?
What are the limitations in the use of graphite, mica, etc.?

(over)

Why is an extremely high flash point oil not necessary in the (*a*) Internal Combustion Engine? (*b*) the H.P. Air Compressor?

Sketch a Gravity Pressure Power Station oiling system.

8. Sketch and detail the operation of any Suction Gas Producer for use with a Gas Engine using a good grade of bituminous coal.

9. Show clearly the analogy between the Compression and Absorption systems of Refrigeration using ammonia.

Sketch the essential of a Compression Plant and put on it the temperatures and pressures to be expected at each stage with an indicator card to be expected, for an assumed set of conditions.

10. Differentiate between the principles of operation of the Diesel, semi-Diesel, and Hvid Engines. Illustrate by sketches and point out the advantages aimed at in the use of each.

11. What in general are the advantages of Multi-Stage Air Compression? Illustrate by indicator cards the definition of Ideal Inter-cooling. What are the advantages in the use of compressed air as a medium of energy transmission.

12. In general, in power plant operation, with a low load factor, the fixed charges are the governing factor, whereas with a good load factor, the operating costs are the governing factor. Discuss fully.

Sketch a typical load curve and show its importance in deciding on the capacity and operating efficiency of the units that should be chosen.

13. What are the limitations of the Venturi as a feed water meter and show how these can be met in a station with a widely varying Load Factor.

14. Describe fully the sphere of the (1) Bleeder and (2) the Mixed Pressure Turbine; and hence account for their general use in special sets of conditions.

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ENGINEERING

Fourth Year—Electrical

ALTERNATING CURRENT MACHINERY

1. A sine wave of e.m.f. having an average value of 60 volts is applied to a circuit containing an inductance of .01 henry and a resistance of 5 ohms. The e.m.f. is supplied from an alternator having 6 poles and running at 500 r.p.m.

What will the instantaneous value of the current be at 1.026 seconds after the e.m.f. wave had passed through its maximum positive value.

2. An e.m.f. of $E=80+60j$ volts is applied to the terminals of a consuming device consisting of 3 circuits in parallel. In the first circuit there are a resistance of 200 ohms and an inductive reactance of 300 ohms, in the second circuit there is a condenser of 9 microfarads capacity, and the third circuit contains an impedance of $100+50j$ ohms. Find the current in the main line, the power factor and the power delivered. Frequency 60 cycles.

3. (*a*) Show how two single phase wattmeters may be used to measure the power in an unbalanced three-phase circuit. (*b*) Prove the correctness of the method. (*c*) What precautions would be taken in making the connections and in taking the readings?

4. (*a*) Define "Form Factor," "Distribution Factor," and "Short Pitch Winding," and explain briefly how each affects the voltage of an alternator.

(*b*) In a three-phase delta connected alternator the total number of turns in series is 200. The winding is distributed in 2 slots per phase per pole. The flux per pole is one million lines. The form factor is 1.05. The pitch is 92 per cent. What is the terminal voltage at a frequency of 60 cycles?

(over)

5. Describe briefly one method of determining the regulation of an alternator without actually running a full load test.

6. Give a brief explanation of the principle of operation of a single phase synchronous motor.

(*b*) What methods are used for starting synchronous motors?

(*c*) What must be the capacity of a synchronous condenser to raise the power factor of a load of 300 kilowatts from 60 per cent to 90 per cent? Neglect losses in the condenser.

7. (*a*) Show how you would connect 3 single phase transformers to transform from 3-phase to 6-phase to supply a rotary convertor.

(*b*) If the 3-phase line voltage is 2200 and the rotary convertor D.C. voltage is 400, what would the ratio of the transformers be?

(*c*) Show how 2 single-phase transformers would be connected to transform from 2-phase to 3-phase.

(*d*) If the capacity of each transformer in (*c*) is 15 K.V. A. what load in K.V.A. would the pair carry with normal temperature rise?

(*e*) If 60 cycle transformers were used on a 25 cycle system at their rated voltage, how would their operation be affected?

8. Explain the principles of operation of a polyphase induction motor and show what effects are obtained by the use of adjustable resistance in the secondary.

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ELECTRICAL ENGINEERING

Fourth Year

ELECTRIC LIGHTING

1. Define: Candle Power, Lumen, Spherical Reduction Factor.

2. Describe briefly the various stages of development of the incandescent lamp, explaining fully why a higher efficiency is obtainable with a tungsten than with a carbon lamp, and with a nitrogen filled tungsten than with a vacuum type.

3. Calculate the horizontal illumination on a horizontal plane midway between two lamps suspended at a height of 9 feet above the plane and at a distance apart of 10 feet. The candle power of the lamps is uniform in all directions and has a value of 80.

4. Show how the voltage at the end of a feeder may be read on a voltmeter in the power house:
(*a*) For a d.c. feeder.
(*b*) For an a.c. feeder.

5. (*a*) Three transformers connected in delta are capable of carrying a load of 300 K.W. What load could be carried by two of these transformers connected in "V." Explain by means of a vector diagram.
(*b*) Two 50 K.V.A. transformers, with Scott connections, are used to transform from 2200 volts, 3 phase, to 220 volts, 2 phase. What is the maximum load in K.V.A. that they will be able to carry without abnormal heating? Explain by vector diagram.

6. A line consisting of copper wires is strung between rigid supports 250 feet apart. The maximum tension in the wire is not to exceed 1200 lbs. If the wires are strung at a temperature of 68° Fahrenheit and the lowest temperature to be encountered is —35°, what must the initial sag be?

(over)

Neglect wind and sleet and take the linear coefficient of expansion of copper = 0.0000095. The weight per foot of the wire is 0.3195 lbs.

7. Explain the principles of a Tyrrell Regulator for regulating the voltage of an alternator and a Polyphase Potential Regulator for regulating the voltage of a 3 phase feeder. Full diagrams of connections of the actual apparatus need not be given.

8. Define Load Factor, Diversity Factor, Demand Factor, and give instances of the kinds of problems into the solutions of which these factors enter.

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ARCHITECTURE

First Year

ELEMENTS OF ARCHITECTURE

NOTE—Illustrate with careful, neat, freehand sketches, when possible.

1. What part do mouldings play, structurally and esthetically, in buildings; what shapes do they take; and in what sequences are classic mouldings used?

2. What is an "order;" how did it originate; and what are the functions of its several parts?

3. What are the differences in character and in main features between the several orders?

4. What version of the orders is most in use; how was it formulated; and what were its sources?

5. Make a sketch complete (with column cut) of the Doric order with names and dimensions of all parts.

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ARCHITECTURE

First Year

ELEMENTS OF ARCHITECTURE

Note—Illustrate with careful, neat, freehand sketches when possible.

1. Ionic Order: (*a*) What was the origin of the Ionic capital?
(*b*) What forms did it take?
(*c*) How is it modified at the corner of a colonnade?

2. Corinthian Order: (*a*) Draw a complete order with names and dimensions of parts.
(*b*) Draw a detail of one-half of the capital, with plan.

3. What are some short cuts for drawing the orders?

4. Indicate some forms and uses of
(*a*) Pilasters.
(*b*) Pediments.
(*c*) Attics.
(*d*) Balusters.

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ARCHITECTURE

Third Year

THEORY OF ARCHITECTURE

NOTE—When appropriate, make illustrative diagrams or sketches.

1. (*a*) What is a work of art?
(*b*) How do the fine arts make their appeal?
(*c*) How does Architecture agree with and differ from the other fine arts in its impression on the mind?

2. What is the distinction between Architecture and mere building, and what is involved in the artistic nature and equipment of the architect?

3. Give some of the qualities or properties of some of the building materials and discuss their use, treatment, and combination from the artistic standpoint.

4. (*a*) Discuss individuality and continuity in architectural composition.
(*b*) Show how one or the other is emphasized historically.
(*c*) How is unity attained?

5. How may details be used (*a*) to divide building façades into masses, and (*b*) to emphasize certain proportions and certain features?

6. Show diagramatically (*a*) the possible modes of primary massing, and (*b*) of horizontal sub-division.

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ARCHITECTURE

Third Year

THEORY OF ARCHITECTURE

1. What is the object of a discussion of the theory of architecture?

2. What is involved in passing from the design on paper to the executed building?

3. Proportion:

(*a*) What is meant by proportion?

(*b*) How are different forms in buildings harmonized proportionally?

(*c*) How is rhythm exemplified in features and details?

4. What does unity in an architectural composition involve?

5. How has architecture been representative of
(*a*) civilization;
(*b*) the architect;
(*c*) the emotional tone?

6. (*a*) What is style?
(*b*) What is historic style?

7. Planning:
(*a*) How are the parts of a plan classified?
(*b*) What considerations affect each category?
(*c*) What advantage has a good plan?

8. (*a*) What is the meaning of "indication" in plan and in elevation or perspective?
(*b*) What are its uses?
(*c*) What are its methods?

9. What is meant by the plan-type?

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ARCHITECTURE

Third Year

HISTORY OF ARCHITECTURE—RENAISSANCE AND MODERN

Note—Where possible make sketches and mention buildings and architects.

FRENCH

1. (*a*) How was architecture developed in the 17th and 18th Centuries in France and what was its character?

(*b*) Describe one or two buildings.

(*c*) What other arts were stimulated by the activity of architecture?

2. Describe some movements in the 19th Century.

ENGLISH

3. Give some account of Inigo Jones and Sir Christopher Wren and their work.

4. What were some of the causes and the products of classic revival?

BELGIAN AND GERMAN

5. How did the Renaissance express itself in these countries?

AMERICAN

6. What are some of the present day tendencies in the United States?

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ARCHITECTURE

Third Year

HISTORY OF ARCHITECTURE

Renaissance

NOTE—Where possible, illustrate by sketches.

Italy

1. (*a*) How were the arts practised in Italy at the Renaissance and how did Architecture profit by the system?
(*b*) How did Gothic and classic buildings or ruins influence the new style?

2. Give some account of Florentine, Roman and Venetian palaces as to plan and exterior treatment and mention some of their authors.

3. Describe the two great domes of the period in Italy and their construction.

4. Give some account of the men who led in the high Classic period and the decadence which followed.

France

5. Describe the "chateau style" and some of its examples.

6. Compare briefly the styles of Francis I, Henry II, Henry IV and Louis XIII.

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ARCHITECTURE

Third and Fourth Years

HISTORY OF ORNAMENT

Ancient and Mediaeval

NOTE—Where possible illustrate by sketches.

1. (*a*) What are decoration? Ornament? Pattern?
   (*b*) What is pure ornament and how is it classified?
   (*c*) What is applied ornament and how modified?

2. What are the main characteristics of the ornamental systems of the Egyptian, Greek, Roman, Byzantine, Romanesque, Gothic, and Saracenic periods as to (*a*) kind, (*b*) sources of elements, (*c*) degree of conventionalization, (*d*) character? (Tabulate.)

3. What principal materials or media have been used for architectural decoration in the periods enumerated above and how have they affected the architectural forms?

4. What forms does Celtic ornament take; where and how was it carried, and to what was it applied?

5. To what architectural features of Gothic was ornament specially applied and what ornamental motives were used?

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ARCHITECTURE

Third and Fourth Years

HISTORY OF ORNAMENT

1. Give some account of early English Renaissance decoration.

2. Compare the decorative style of Louis XVI, the French Empire and the Adams.

3. Describe some recent innovations in decorative ideas.

4. (*a*) What color modifications do colors undergo?

(*b*) How are they combined to make a proper color scheme for the decoration of a room?

(*c*) What are the characteristics of such a color scheme?

COMPOSITION

5. (*a*) What is meant by the composition of a room?

(*b*) What are the main elements common to nearly all such compositions?

(*c*) What are the general principles which apply?

6. Taking a particular period style at will, describe and discuss its interior decoration.

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ARCHITECTURE

Third and Fourth Years

PLUMBING AND DRAINAGE

NOTE—Omit any two questions except No. 1.

1. Make a plumbing section of the drainage system of a house, having laundry, floor and yard drains in basement, kitchen fixtures in first story, two bathrooms in second, one bathroom in third, the basement fixtures being below the level of the street sewer, but the system draining into it; all traps being back vented. Storm water, from the roof of 2500 sq. ft. to be carried off by the system. Indication of piping and connections may be made by single lines, sizes being noted.

Draw at a larger scale all typical connections, piping fixtures, fittings, devices, supports, and special features, annotated to indicate reasons, precautions, etc.

2. What is water hammer? How is it obviated?

3. Explain the operation of the hydraulic ram and state its advantages.

4. Describe methods and apparatus for filtration of water.

5. Describe types and action of water closets.

6. Describe apparatus and piping for a domestic hot water system.

7. Describe varieties of cocks and valves.

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ARCHITECTURE

Third and Fourth Years

HISTORY OF ART

Note—Omit any *two* questions.

1. How are engravings, etchings, woodcuts, lithographs and fresco paintings made?

2. Where did real paintings begin and what people led the way?

3. Who were the great painters in Italy?

4. Name the half dozen greatest painters of the world and characterize them.

5. What can you say of landscape painting and who were its greatest exponents?

6. Who formed the Fountainbleau school and what did each stand for?

7. What English groups of painters can you mention?

8. What is involved in pictorial composition?

9. What periods have been greatest in sculpture?